Summary of Fisheries Indicators of Southern Bluefin Tuna Stock in 2013

Norio TAKAHASHI and Tomoyuki ITOH

National Research Institutes of Far Seas Fisheries
Fisheries Research Agency

Abstract : Various fisheries indicators were carefully examined to overview the current status of southern bluefin tuna stock. The indicators suggested that the current stock levels for 4, 5, and 6&7 age groups were well above the historically lowest levels of the late 1980s and the mid-2000s. When looking to recent years, the standardized Japanese longline CPUEs for these age classes, especially age classes 5 and 6&7, showed marked increases. The CPUE indices for age 8-11 had declined slightly and gradually since 2008 and upturned in 2012. Age class 12+ CPUEs have also gradually decreased toward 2012 since 2008. The current stock levels for these older age groups are still very low. Many indices indicated low recruitments of 1999 to 2002 cohorts. There were some inconsistencies in recruitment level observed in comparisons between some indicators and the results of the 2005 and 2006 acoustic surveys (corresponding to the 2004 and 2005 cohorts), suggesting that the 2004 and 2005 recruitments were higher than those the acoustic survey indicated. Although there were some ups and downs in trends, both recruitment indices and longline CPUEs indicated that the recruitment levels for the 2006 to 2011 cohorts were also higher than those for the 1999 to 2002 cohorts.

要旨：ミナミマグロの資源状態を概観するために各種漁業指数を精査した。指標は、現在の 4、5、及び 6&7 年齢グループの資源水準が 1980 年代後半と 2000 年代中頃に見られた歴史的最低レベルより十分上にあることを示していた。近年を詳しく見ると、これら年齢クラス、特に 5 歳及び 6&7 歳に対する日本はえ縄船の標準化 CPUE 指数は顕著な増加を見せていた。8-11 歳クラスの CPUE 指数は 2008 年以来、徐々に減少して、2012 年に上昇した。12+歳クラスの CPUE もまた、2008 年以来、徐々に減少してきている。これらのより高齢のグループの現在の資源状態は依然として極めて低いレベルにある。多くの指標は 1999 年級から 2002 年級までの加入が低かったことを示していた。いくつかの漁業指標と 2005 年及び 2006 年の音響調査結果（2004 及び 2005 年級に対応）との間には加入レベルについて矛盾がみとめられた。これは 2004 年と 2005 年の加入量が、音響調査が示す加入量よりも高いことを示唆していた。トレンドにいくらかの増減はあるものの、加入指数及びはえ縄 CPUE はともに、2006 年級から 2011 年級の加入水準も 1999 年級から 2002 年級の加入水準よりも高いことを示していた。

Southern bluefin tuna (SBT, *Thunnus maccoyii*) stock is one of valuable fisheries resources distributed throughout the southern hemisphere. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) is responsible for the management of the SBT stock throughout its distribution. The CCSBT's objective is to ensure, through appropriate management, the conservation and optimum utilization of the stock.

The 2001 Scientific Committee (SC) of CCSBT selected a set of fisheries indicators to overview the SBT stock status (CCSBT 2001). These indicators have been revised and used in past Stock Assessment Group (SAG), SC and Extended Scientific Committee (ESC)[1] meetings to examine whether unexpected changes of stock status requiring urgent full stock assessment occurred. Also, the 3rd Meeting of Management Procedure Workshop in 2004

[1] ESC meetings have been organized for the SC after Taiwan became a CCSBT member.

agreed to review fisheries indicators every year to monitor whether the SBT stock status stays within an expected range of uncertainty which the operating model considered (CCSBT 2004). This document summarizes results of updated fishery-dependent indicators and our overall interpretations. Some fishery-independent indices based on research surveys were also presented. It should be noted that conclusions in the reports of the Japanese Market and Australian Farming Investigation Panels are not taken into account of in this summary because how to incorporate information of catch anomalies into past CPUE data is difficult. The ESC agreed to use the new growth curve proposed by Australia (Polacheck et al. 2002) from the 2011 Data Exchange. All CPUE indicators in this document based on catch at age data by the new growth curve.

1. Japanese longline CPUE[2]:

<u>Nominal CPUE</u>

Nominal CPUE data by age group of Japanese longline fishery include those of joint-venture with Australia and New Zealand (Fig. 1-1). Caution is necessary for interpretation of age 3 and 4 CPUE in 1995 and 1996 because of direct impacts of non-retention of smaller fish than 25 kg occurred in these two years. The most recent year's data exclusively rely on information collected by the Real Time Monitoring Program (RTMP) which covers only SBT targeting vessels. When all the other non SBT-targeting vessels' data (based on logbooks) become available and are included in the existing dataset the following year, CPUE of the most recent year tends to drop slightly (Takahashi et al. 2001). So the most recent year's CPUE must be also looked at with caution. However, those differences have decreased gradually and almost no difference has been found in recent years because the RTMP covers more than 95% of efforts in SBT distribution. There was no such drop observed for all age classes in 2011 (Data were not shown).

CPUE in recent years must be further looked to carefully because Japanese longline fishery has introduced Individual Quota (IQ) system since 2006. Changes in the number of catch and the distribution pattern of effort before and after 2006 were examined and discussed in detail in Itoh (2013).

When focusing on trends for the recent five or six years, nominal CPUE for age 3 fluctuated around the past 5-year mean (Fig. 1-1). The 2012 value for this age was similar to the mean. CPUE for age 4 largely increased between 2008 and 2009, and then decreased toward year 2012 of which CPUE was at the same level of the past 5-year mean over 2006-10. Although age classes 5, 6&7, and 4+ had declined since the early 2000s hitting the bottom in 2006, recent CPUEs for these ages showed increasing trends, except for age 5. The 2012 values for these ages were similar to or higher than the past 5-year averages. Nominal CPUEs for age classes 8-11 and 12+ declined from 2008 to 2011. The recent CPUE value for 12+ was lower than the past 5-year average while the CPUE for 8-11was at the same level of the 5-year average.

Trends of nominal CPUE of Japanese longline by cohort were plotted in Figs. 1-2 and 1-3. Fig. 1-2 is a comparison of nominal CPUE of juveniles among different cohorts and Fig. 1-3 compares decrease rate by cohort in the logarithmic scale. CPUE for age 3, 4 and 5 fish generally showed consistent trends, suggesting that age 3 CPUE could be used as an indicator of relative cohort strength, although some variations in trend and divergence from

[2] <u>C</u>atch <u>p</u>er <u>U</u>nit <u>E</u>ffort. In southern bluefin tuna case, CPUE is the number of catch per 1000 hooks.

trends of other two CPUEs have been observed for age 3 in recent years (Fig. 1-2). Cause(s) of this variation and divergence have been unknown (A partial cause might be release of small fish in recent years). A large decline of 1999 cohort (2000 acoustic survey in Fig. 3-1) was not be able to detected by age 3 CPUE.

Overall levels of CPUE across age 3 to 11 by cohort can be grouped as the periods of 1980-1986, 1987-1992, 1993-1999, 2000-2003 and 2004-2008 cohorts (Fig. 1-3). Within each period, variations of the CPUE levels were small (except for age 3 CPUEs in 2000-2003 cohorts) and the decease rates were similar. For 2000-2003 cohorts, the catch rates of age 3 varied considerably. These large variations in catch rate would be due to change in catchability and/or population fluctuation. The 1987-1992 cohorts showed more drastic declines than other cohorts, which was probably due to targeting towards smaller fish in the early 1990s caused by depleted stock status of cohorts recruited in pre1987 years and less structured management schemes at that time. The cohorts recruited from 1993 to 1999 showed slower decline rates, suggesting a reduced level of exploitation rates for these cohorts. Fig. 1-3 also indicates acute decreases of CPUE level for age 3 fish of 2000-2002 cohorts to about the same or lower levels comparable to those experienced by the early 1980s cohorts, while showing that 2003-09 cohorts were similar to the late 1980s levels (see also Recruitments section below). Cause(s) of these weak 2000-2002 cohorts is still unknown, whether it would be a reflection of change in oceanographic and/or fish availability, or it be an indication of a consequence of fishing pressure. Although the CPUE levels for age 3 of 2005-2008 cohorts varied depending on cohorts, the CPUE levels for age 4-6 were similar to or higher than ones of any cohorts in past.

Age compositions of nominal CPUE for 2012 (Area 8) and 2013 (Areas 4, 7 and 9) obtained from RTMP were plotted in Fig. 1-4. Past years' data are shown for comparison. In Area 7/April and May, CPUEs for age 6 and 7 in 2013 were lower than those in previous years. In contrast, CPUEs for the same age classes in Area 9/April to July of 2013, and in Area 8/September to November of 2012 were higher than those in previous years. CPUEs for ages younger than 4 in Area 9/April, June and July of 2013, and in Area 8/September and October of 2012 decreased from those in previous years.

Substantial CPUE reductions for ages 9 to 12 in some Area/month strata, especially for the 2009 to 2011 periods (Fig. 1-4), corresponded to weak recruitments of which the acoustic monitoring survey had detected drastic declines between 1999 and 2002 (Fig. 3-1). In some other Area/month strata, CPUE values for ages 7 and 8 in 2012 and 2013 were higher than those in previous years, corresponding to cohorts that came after the weak recruitments between 1999 and 2002.

<u>Standardized CPUE</u>

Two GLM standardized CPUE indices of w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) were updated (Fig. 1-5) using the same method as described in Takahashi et al. (2001; see also Takahashi 2008 for correction of editorial errors in the formulae for calculating the indices). The standardization model used was the same as that of Nishida and Tsuji (1998). Estimates of the CPUE indices for 2012 (the most recent year) were based not on logbooks but RTMP data only, and thus should be looked at with caution as described in the Nominal CPUE section above (Takahashi et al. 2001). These estimates may be changed when logbook data become available the subsequent year. Further, as mentioned above, recent years' CPUE must be examined carefully because Japanese longline fishery has introduced IQ system since 2006 (Itoh 2013).

Looking to trends of the recent seven years, the w0.5 and w0.8 indices for age 3 showed increasing trends from 2006 to 2008, and then decreased for two years in a row (Fig.1-5a). Upturns for this age in 2007 and 2008 inconsistently corresponded to low recruitments of 2004 and 2005 cohorts observed respectively in the 2005 and 2006 acoustic survey of the Recruitment Monitoring Program (Fig. 3-1), but were more or less consistent to results from the trolling survey in 2005 and 2006 (Fig. 3-2). Decline for age 3 from 2008 to 2010 were not observed in the trend of the trolling survey between 2006 and 2008 (Fig. 3-2). The 2012 indices for age 3 increased to values higher than the past 5-year averages over 2007-11. The CPUE index for age 3 varies year to year, especially in recent years (see Fig. 1-2), and thus its trend is not necessarily consistent with ones for age 4 and 5 by various reasons (e.g., incomplete recruitment of age 3 fish into Japanese longline fishery, small fish release in recent years). Therefore, the age 3 indices should be looked at and interpreted with caution.

The indices for the age 4 continuously increased from 2007 to 2009, decreased and then increased toward 2012 (Fig. 1-5b). The low index values for age 4 observed in 2006 corresponded to low recruitments (2002 cohorts) observed in the acoustic survey conducted in 2003 (Fig. 3-1). The acoustic survey was not conducted in 2004 corresponding to the 2003 cohort (Fig. 3-1). However, the index values for age 3 in 2006 and for age 4 in 2007 suggested a possibility that, although its recruitment level was still low, 2003 cohort was not much weak as that of 1999-2002, showing some upturns (Figs. 1-5a and b). Furthermore, similar upturn patterns were observed for age 4 in 2008 and 2009 corresponding to the 2004 and 2005 cohort (Fig. 1-5b) while the acoustic surveys conducted in 2005 and 2006 showed low indices (Fig. 3-1). A similar increasing trend was also observed in the trolling survey in 2005 and 2006 (Fig. 3-2). The 2012 indices for age 4 were higher than the past 5-year means over 2007-11.

The CPUE indices for 5 and 6&7 age groups have shown uninterrupted increasing trends since 2007, except for age 5 in 2011 and 2012 (Figs. 1-5c and d). These increases may be corresponding to ones observed in the trolling survey between 2002 and 2006 (Fig. 3-2). The low index values for these ages observed in 2007 corresponded to the low recruitment in the 2001, 2002, and 2003 acoustic survey (2000, 2001, and 2002 cohorts) (Fig. 3-1). All the indices for age classes 5 and 6&7 in 2012 were much above the past 5-year means. The CPUE index values for age 8-11 have declined slightly and gradually since 2008 (Fig. 1-5e). This may correspond to low recruitments of 1999-2002 cohorts observed in the 2000-2003 acoustic surveys (Fig. 3-1). The 2012 indices for this age class were increased to levels slightly higher than the past 5-year average. This upturn might indicate that 2003 to 2004 cohorts which came after the weak recruitments between 1999 and 2002 have started entering into the 8-11 age group. The CPUE indices for age 12+ showed a gradual decline from 2008 to 2012 (Fig. 1-5f). The indices in 2012 for this age group were lower than the 5-year averages.

The CPUE indices for age 4+ group have continuously increased since 2007 when the historically lowest level of CPUE was observed (Fig. 1-5g). The indices in 2012 for age 4+ were much higher than the past 5-year averages over 2007-11.

Fig. 1-6 shows trends of the CPUE indices for age 4+ calculated using the Core Vessel data and the standardization models agreed in the CPUE modeling Group (CCSBT 2010, Itoh et al. 2013). The "Base" series is the one used for the operating model (OM) conditioning and management procedure (MP) inputs in the ESC. Other two series, namely "Reduced Base" and "Base with SxS," are used for monitoring to check if there is any unexpected thing happened to both SBT and the fishery along with the Base series. “Reduced Base” indices were calculated by using the same data and standardization model as “Base” except that by-catch and year interaction terms were excluded from the model. “Base with SxS” indices based on the same standardization model as “Base” but used shot-by-shot data. Trends of

"Base" indices had patterns similar to that of the CPUE series using the Nishida and Tsuji model and all vessel data presented above, except for the last two years (compare Figs. 1-5g and 1-6).

Spatial-Temporal (ST) windows CPUE for age 4+

“Spatial-temporal (ST) windows” CPUE index for age 4+ (Takahashi et al. 2002) was also updated using the new method as described in Takahashi (2006). “ST windows” represent Area 9/May and June, and Area 8/September and October. By inspecting historical Japanese longline catch/effort data, these spatiotemporal strata were so defined as to persistently observe substantial effort of the longline fishery. Recently, however, it was noted that the assumption on such persistency in the ST windows concept was no longer valid due to changes in operation pattern of Japanese longliners (Takahashi and Itoh 2012). Given this, the ESC agreed that while the ST windows series had been a useful “extreme” series for contrast with the base series, there was now a need to replace the ST Windows series (CCSBT 2012). Yet we consider that it may be useful to continue monitoring the ST windows series because the series would still be able to capture some aspect of stock trend, and thus we decided to include this series in this document.

The trend of the “ST windows” is shown in Fig. 1-7. The updated index more or less has kept the same level ranging between 0.5-1.0 values for the past 20 years. For the last five years, although the index still stays at levels lower than or same as the historical low levels observed in the late 1980s, the index has gently increased since 2007. The index value in 2012 was in the similar level to the past 5-year average.

The ST windows series had been used for robustness tests of MP development in the ESC because the series can be considered as one extreme of an envelope for the "Base" series (see above), given it had formed the recent lower bounds of other CPUE-based series (CCSBT 2010).

2. Australia purse seine fishery:

Changes of catch per efforts and age composition of Australia purse seine fishery catches were plotted in Figs. 2-1 and 2-2. Although interpretation of the CPUE of this fishery is contentious, monitoring changes of the CPUE merits having some insight into status of juvenile fish. Both catch per shot and catch per searching hours appeared to be gradually declining from 1999/00 to 2008/09 seasons (Fig. 2-1). In part, this decline of juvenile fish probably may correspond to low recruitments that were observed in the acoustic survey index and Japanese longline CPUE (Figs. 1-1, 1-4, and 1-5 for the longline, and Fig.3-1 for the acoustic survey). There was a large upturn of the CPUE observed in 2009/10 season, and then the CPUE continued to decline in 2010/11 and 2011/12 seasons in a row. Both CPUEs in 2011/12 season were lower than the past 5-year means over 2007-11.

Generally the proportions for age 2 fish between 2004 (03/04 season) and 2012 (11/12 season) were greater than any for previous years (Fig. 2-2). Contrary, proportions for age 3 and 4 decreased for the same years. In 2012, the age composition largely increased for age 2, and decreased for age 3. Other than that, no strong signal was observed in the age composition of the purse seine catches. It should be noted that applying cut points of the new growth curve (as from the 2010 SC) made almost all age 1 fish proportions disappear from the age composition chart. This is because fish being classified as age 1 by the previous growth curve are now categorized as age 2 by the new growth curve.

The trends of both aerial (Eveson et al. 2013) and commercial spotting (SAPUE; Farley and Basson 2013) survey indices in the Great Australian Bight (GAB) are shown in Fig. 2-3. These indices monitor surface abundance of age 2-4 fish combined distributed in the GAB region. The aerial surveys have been conducted by Australia under the Recruitment Monitoring Program since 1993. Full scale line transect aerial surveys were suspended between 2001 and 2004. Although a limited number of lines was continued to be surveyed during this period, it was concluded that the indices of limited scale survey were not able to provide information comparable to the full scale aerial survey. Overall the aerial survey index (AI) showed the moderately declining trend from 1993 to the early 2000s. AI values were more or less stable in the rest of the 2000s. The AI markedly increased in 2010 and 2011, two years in a row, then largely dropped in 2012 and then upturned in 2013. The 2013 value of AI was higher than the past 5-year average over 2008-12 and a similar level to the mid-1990s estimates. The overall trend of SAPUE appeared to be increasing during 2004-2011 period. The 2011 SAPUE also declined in 2012 and then increased in 2013. The 2013 value of SAPUE was still below the past 5-year average.

3. Recruitments:

Acoustic survey

Acoustic survey of the Recruitment Monitoring Program was aimed to monitor changes in relative abundances of age 1 fish moving through the survey area in the southwestern coast of Australia. This index represented the age 1 fish abundance within the survey area standardized with 15 days' survey period. The index showed a drastic decline in 2000 and stayed at very low levels which were non-estimable because of lack of records identified as SBT with a certain estimated biomass with sonar (Fig. 3-1). No field activities were conducted in 2003/2004 season, and the survey ended in the 2005/2006 season.

As explained above, cohorts showing the extreme low abundance levels in the 2000, 2001, 2002, 2003, 2005, and 2006 surveys have been available to Japanese longline fishery and mostly showed substantially low CPUEs (Figs. 1-1, 1-4 , and 1-5). It has been common understanding in the CCSBT ESC that the recruitment trend detected by the acoustic surveys reflected the real situation, and we have seen at least four years' low longline CPUEs coming in sequence which were resulted from the low recruitments of 1999, 2000, 2001, and 2002 cohorts (corresponded to cohorts detected by the 2000-2003 surveys). This had caused devastative impacts on both SBT stock and longline fishery. Now these cohorts have entered to age classes 8-11 and 12+ and appeared in CPUE series between 2007 and 2012, showing somewhat gently declining trends (Figs. 1-5e and f).

However, there is some inconsistency observed for 2004 and 2005 cohorts. The CPUE indices for age 3 in 2007 and 2008, for age 4 in 2008 and 2009, for age 5 in 2009 and 2010, and for age 6&7 in 2010 to 2012 were apparently at the same levels of or higher than that of the late 1990s and the early 2000s (Figs. 1-5a, b, c, and d) whereas the 2005 and 2006 acoustic surveys indices indicated low recruitments (Fig. 3-1). Further, although we tend to assume that 2003 cohort (not acoustic-surveyed) was similarly weak because the acoustic survey indices of previous and following years' indicate low recruitments (Fig. 3-1), the corresponded CPUEs for age3 in 2006, for age 4 in 2007, for age 5 in 2008, and for 6&7 age class in 2009 and 2010 showed upturns (Figs. 1-5a, b, c and d), suggesting that the 2003 cohort may not be so weak as the previous ones. Thus, considering such uncertainty about influence of 1999-2005 cohorts observed as low levels in the 2000-2006 acoustic survey, we need to monitor other indicators synthetically and carefully along the acoustic survey index for next several years.

The Recruitment Monitoring acoustic survey ended in the 2005/2006 season due to budget matter and was replaced by much lower-cost trolling survey to monitor relative abundance of age 1 fish (see below).

Trolling survey

Since a vast amount of costs was necessary for conducting the Recruitment Monitoring acoustic surveys (above), a recruitment index of age 1 fish estimated from results of much lower-cost trolling surveys has been currently being developed. Details of the survey design, estimation method, results and its interpretation were documented in Itoh (2007) and Itoh et al (2013). Fig. 3-2 illustrates the trend of the trolling catch index. The median trend of the trolling index based on bootstrap sampling increased from 2005 to 2008, declined toward 2010, and then largely fluctuated in recent years, although bootstrapped 5% and 95% quantiles were quite wide (indicated by lower and upper lines). It should be noted that the length frequency distribution observed in the 2012 survey was quite different from those in previous years (Itoh et al. 2012). Thus, it would not be appropriate to assess the recruitment level simply based on the index value in 2012.

Cohorts of 1999, 2000, and 2001 (2000, 2001, and 2002 surveys) showed considerably low levels of recruitment. These low recruitment levels were consistent with the ones observed in results of the acoustic surveys (Fig. 3-1). In contrast, the trolling indices for 2002, 2004, and 2005 cohorts (2003, 2005, and 2006 surveys) inconsistently showed higher levels of recruitment than the acoustic survey did. However, the increase levels of 2004 and 2005 cohorts were compatible with upturns observed in the longline CPUE indices for age 3 fish in 2007 and 2008, for age 4 in 2008 and 2009, for age 5 in 2009 and 2010, and for age 6&7 in 2010 to 2012 (Figs. 1-5a, b, c, and d). No survey was conducted in 2004, so any speculation on recruitment status of 2003 cohort could not be drawn from the trolling catch index.

As compared above, the levels of trolling indices were compatible with that of other indices (e.g., acoustic indices, Japanese longline CPUE), of course there were some exceptions though. Thus, some usefulness of the indices to monitor age 1 recruitment was recognized. Reliability of the trolling indices is still being verified and it is necessary to compare these indices with CPUE for corresponded cohorts recruited into longline fishery for further verification. The trolling indices may not be used as rigorous quantitative indicators for recruitment. However, they can be used as indicators to detect some qualitative signals of the recruitment level, indicating “high”, “medium”, or “low.”

4. Indonesian Catch (Spawning ground fishery) :

Indonesian SBT catch both in number and weight as well as catches by two age groups, age 8-16 and age 17 and older, changed between years (Fig. 4-1).

Catches for age class 17+ were higher than ones for 8-16 ages throughout the 1990s. In contrast, many of yearly catches for the 17+ group have been similar to or much lower than ones for 8-16 ages since 2000/01 season. Spiky increases of catch in 2001/02, 2004/05 and 2006/07 seasons may be mainly due to large increase of younger age classes. No information has been available to conclude whether this replacement in the age composition reflected changes in fish abundance or changes in fishing practices.

The catch trends of both in number and in weight for age 8-16 and 17+ combined appeared to gradually decline with fluctuations from 1997/98 season to the present.

The low levels of the older portion and the gradual declining trend of Indonesian catch since 2001/02 season raise some concerns of potential low reproduction in recent years.

5. Overall Conclusion:

Fisheries indicators examined generally supported a view that the current stock levels for 4, 5, and 6&7 age groups were well above ones observed in the late 1980s and the mid-2000s which were the historically lowest stock levels. The standardized Japanese longline CPUE indices for these age classes, especially 5 and 6&7, showed marked increases. The CPUE indices for age 8-11 group have declined slightly and gradually since 2008 and then upturned in 2012. CPUEs for age class 12+ have also decreased gradually toward 2012 since 2008. The current stock levels for these older age groups are still very low similar to ones observed in past. Many indicators suggested considerable low recruitments in past years but differ in indication of how low they were. The acoustic indices suggested continuous low recruitments for four years (the 2000-2003 acoustic surveys corresponding to the 1999-2002 cohorts). Agreed with the results of the surveys, the longline CPUE indicators suggested considerable decline of recruitments of 1999-2002 cohorts. However, there were some inconsistencies in recruitment level observed in comparisons between some indicators and the results of the 2005 and 2006 acoustic surveys (corresponding to the 2004 and 2005 cohorts), suggesting that the 2004 and 2005 recruitments were higher than those the acoustic survey indicated. Although there were some ups and downs in trends, both recruitment indices and longline CPUEs indicated that the recruitment levels for the 2006 to 2011 cohorts were also higher than those for the 1999 to 2002 cohorts. The trends of the recruitment surveys and CPUE-based indicators in recent 5 years were summarized in Fig. 5-1. The indices of spawning stock based on Indonesian catch were difficult to interpret and thus no specific conclusion was drawn. Considering uncertainty inherent in all the indicators inspected, further careful monitoring and examining both fishery-dependent and fishery-independent indicators are continuous tasks with priority.

References

Anon. (CCSBT). 2001. Report of the sixth meeting of the Scientific Committee, 28-31 August 2001 Tokyo, Japan. The Commission for the Conservation of Southern Bluefin Tuna, Canberra, Australia. 51 pp.

Anon. (CCSBT). 2004. Report of the third meeting of the Management Procedure Workshop, 19-24 April 2004 Busan, Republic of Korea. The Commission for the Conservation of Southern Bluefin Tuna, Canberra, Australia. 86 pp.

Anon. (CCSBT). 2010. Report of the fifteenth meeting of the Scientific Committee, 11 September 2010 Narita, Japan. The Commission for the Conservation of Southern Bluefin Tuna, Canberra, Australia. 119 pp.

Anon. (CCSBT). 2012. Report of the seventeenth meeting of the Scientific Committee, 27-31 August 2012 Tokyo, Japan. The Commission for the Conservation of Southern Bluefin Tuna, Canberra, Australia. 87 pp.

Eveson, P., J. Farley, and M. Bravington. 2013. The aerial survey index of abundance:

updated analysis methods and results for the 2012/13 fishing season. CCSBT-ESC/1309/10.

Farley, J. and M. Basson. 2013. Commercial spotting in the Australian surface fishery, updated to include the 2012/13 fishing season. CCSBT-ESC/1309/09.

Itoh, T. 2007. Some examination on the recruitment index of age 1 southern bluefin tuna derived from the trolling survey. CCSBT-ESC/0709/39.

Itoh, T. 2013a. Change in operation pattern of Japanese southern bluefin tuna longliners in 2012. CCSBT-ESC/1309/28.

Itoh, T, O. Sakai, and N. Takahashi. 2013. Description of CPUE calculation from the core vessel data for southern bluefin tuna in 2013. CCSBT-ESC/1309/29.

Itoh, T., O. Sakai, and D. Tokuda. 2012. Report of the piston-line trolling monitoring survey for the age-1 southern bluefin tuna recruitment index in 2011/2012. CCSBT-ESC/1208/33.

Itoh, T., O. Sakai, and D. Tokuda. 2013. Report of the piston-line trolling monitoring survey for the age-1 southern bluefin tuna recruitment index in 2012/2013. CCSBT-ESC/1309/27.

Nishida, T., and S. Tsuji. 1998. Estimation of abundance indices of southern bluefin tuna (Thunnus maccoyii) based on the coarse scale Japanese longline fisheries data (1969-97). CCSBT/SC/9807/13.

Polacheck, T., G. M. Laslett, and J. P. Eveson. 2002. An integrated analysis of the growth rates of southern bluefin tuna for use in estimating catch at age in stock assessments. CCSBT-ESC/0209/35.

Takahashi, N. 2006. Future use of “ST windows” index calculated by a new method: A proposal. CCSBT-ESC/0609/47. 3 pp.

Takahashi, N. 2008. Data and method used to calculate B-ratio Proxy (w0.5) and Geostat Proxy (w0.8) CPUE Series. A methodology document submitted to the CCSBT Secretariat on 27 June, 2008. 3 pp.

Takahashi, N., and T. Itoh. 2012. Comparison between “ST windows” index and Core vessels CPUE indices by different Area/month combinations. CCSBT-ESC/1208/42.

Takahashi, N., H. Shono, and S. Tsuji. 2002. Some consideration on Japanese longline CPUE as a potential input to management procedures. CCSBT-CPUE/0203/09. 11 pp.

Takahashi, N., S. Tsuji, T. Itoh, and H. Shono. 2001. Abundance indices of southern bluefin tuna based on the Japanese longline fisheries data, 1969-2000, along the interim approach agreed for the 2001 assessment. CCSBT-SC/0108/28. 39 pp.

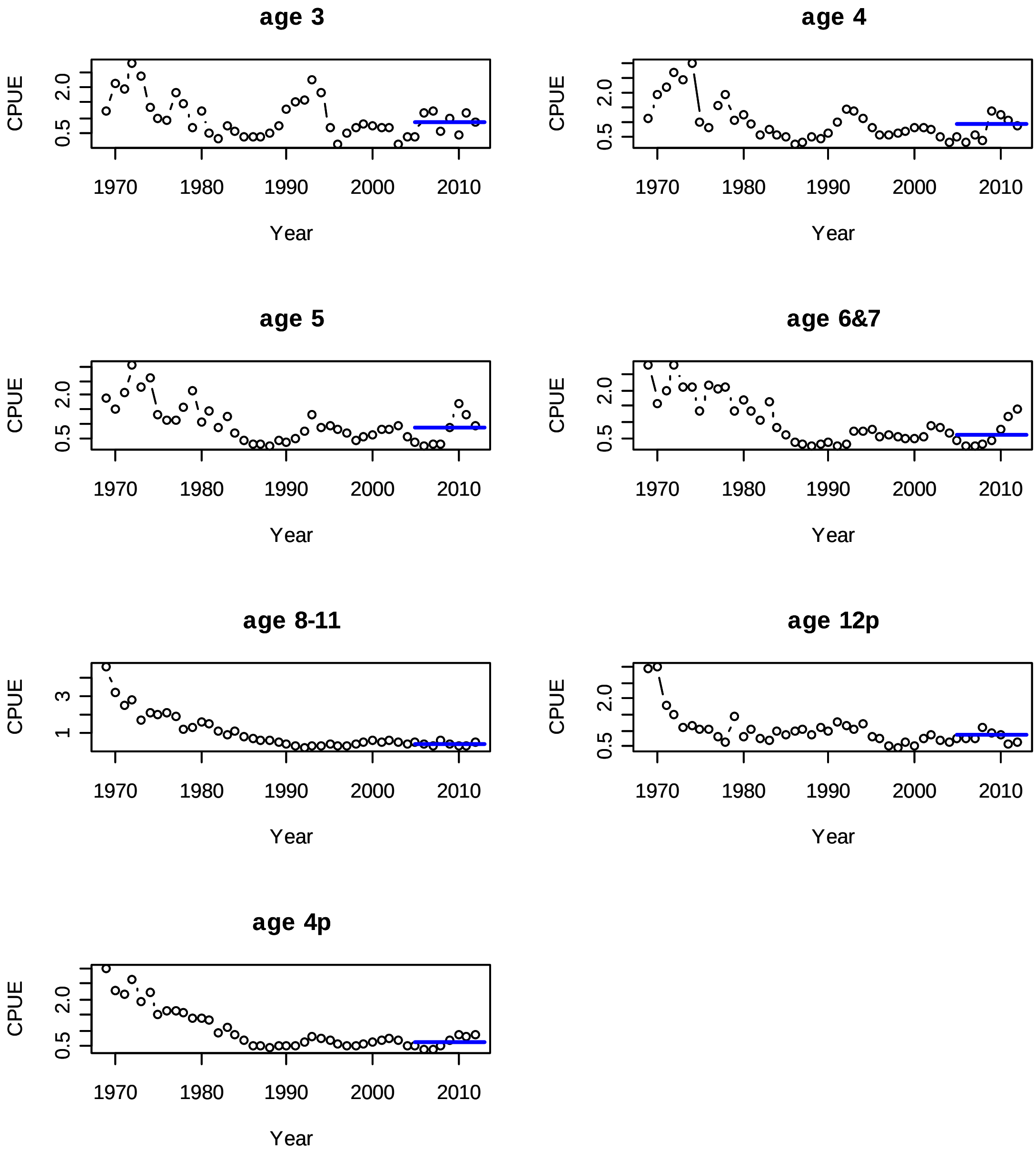


Fig. 1-1. Nominal CPUE of Japanese longline fishery by age groups. The horizontal lines indicate the past 5-year averages over 2007-11.

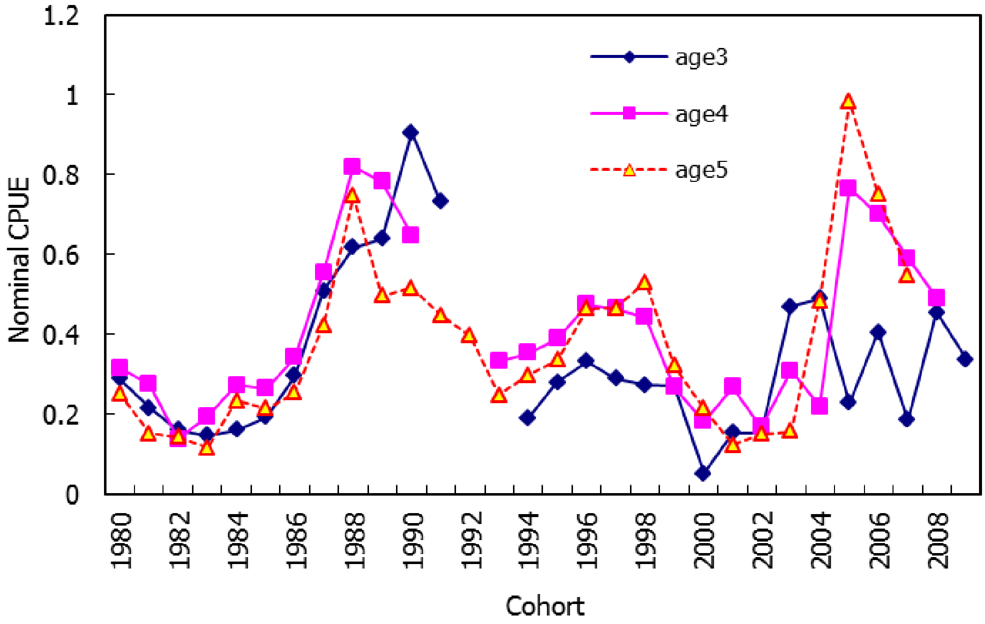


Fig. 1-2. Nominal CPUE of Japanese longline fishery by cohorts for age 3, 4, and 5.

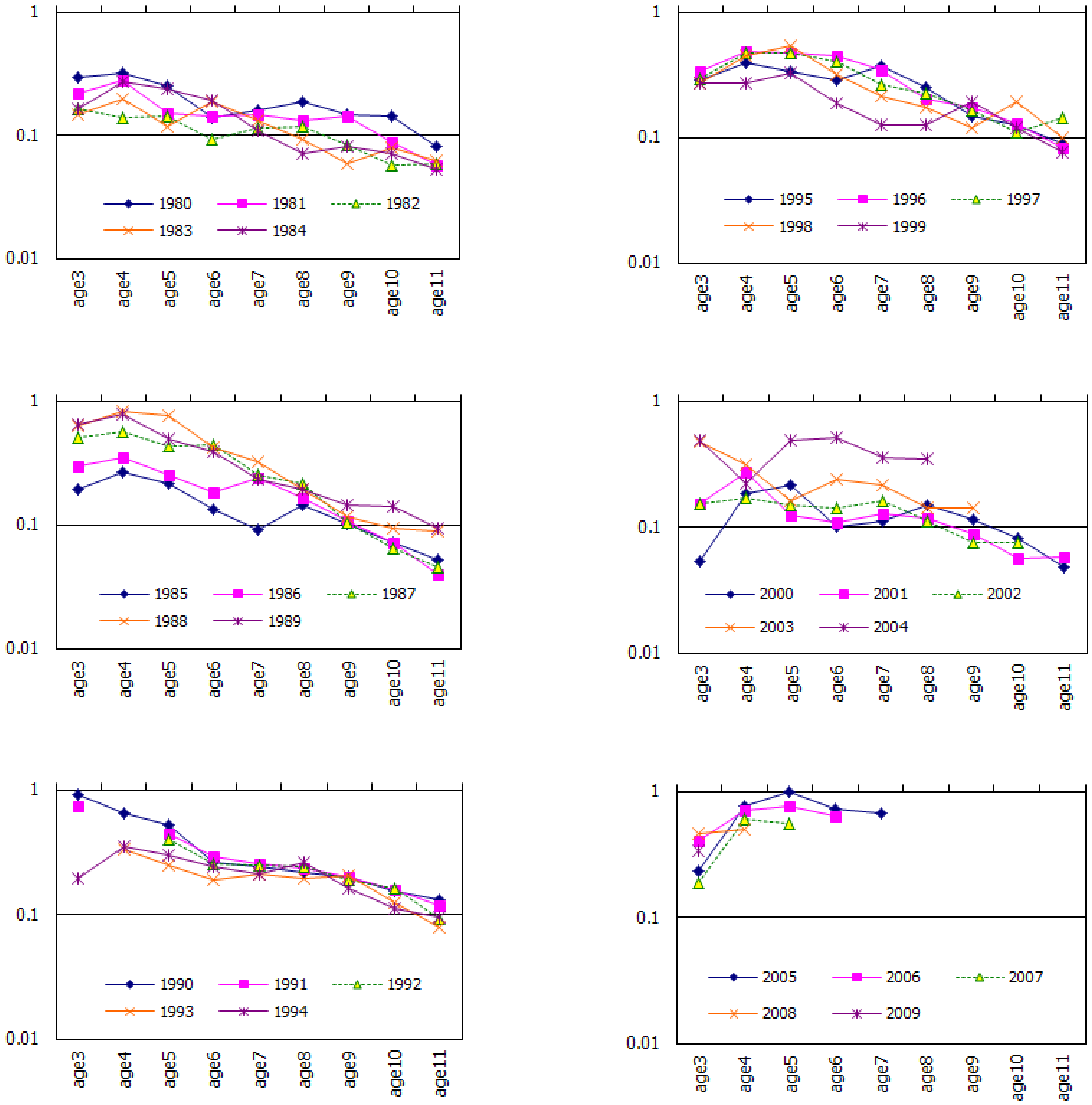


Fig. 1-3. Nominal CPUE of Japanese longline fishery by cohorts in log-scale.

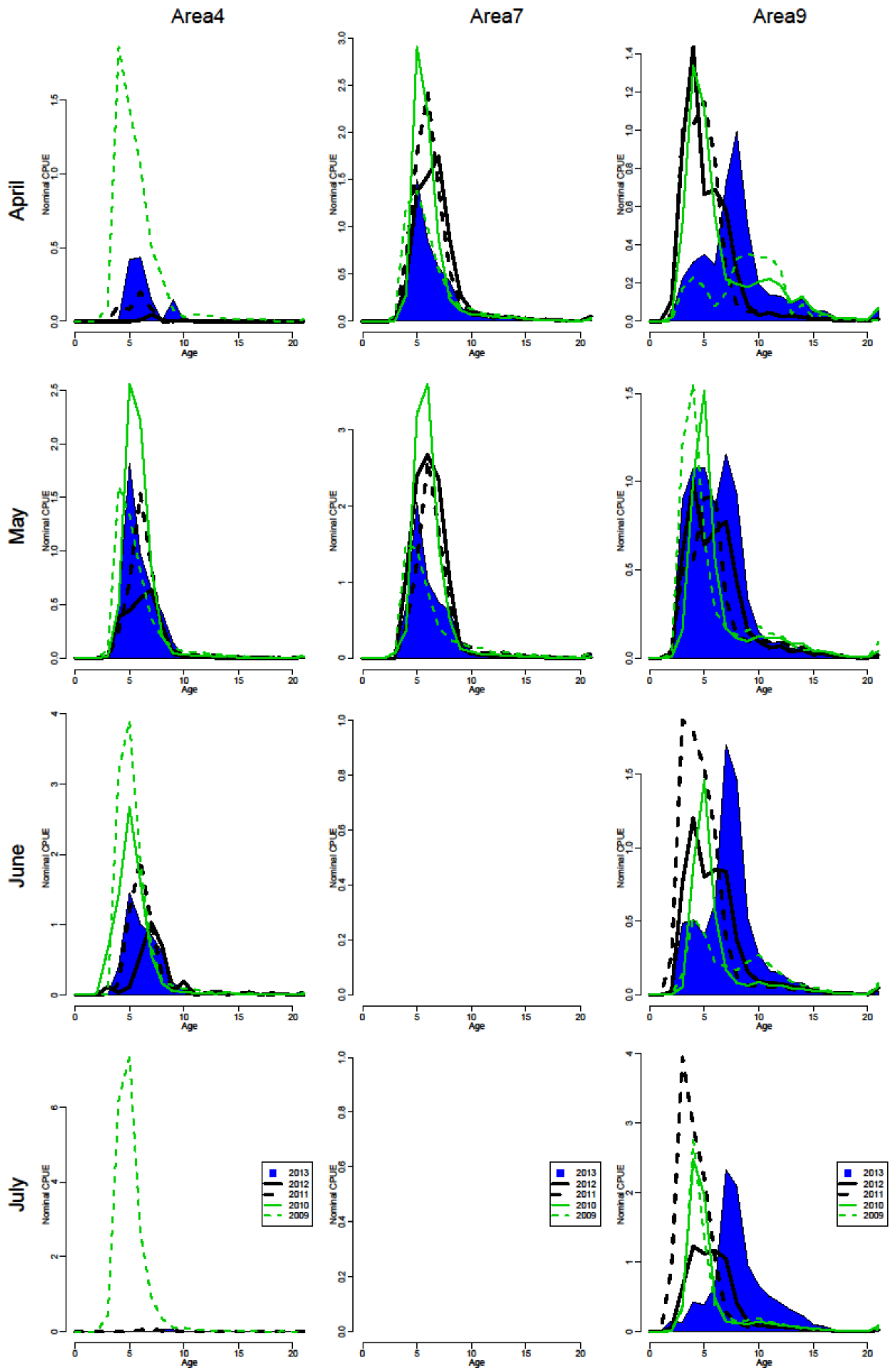


Fig. 1-4. Age composition of nominal CPUE of RTMP data for recent five years by month and areas.

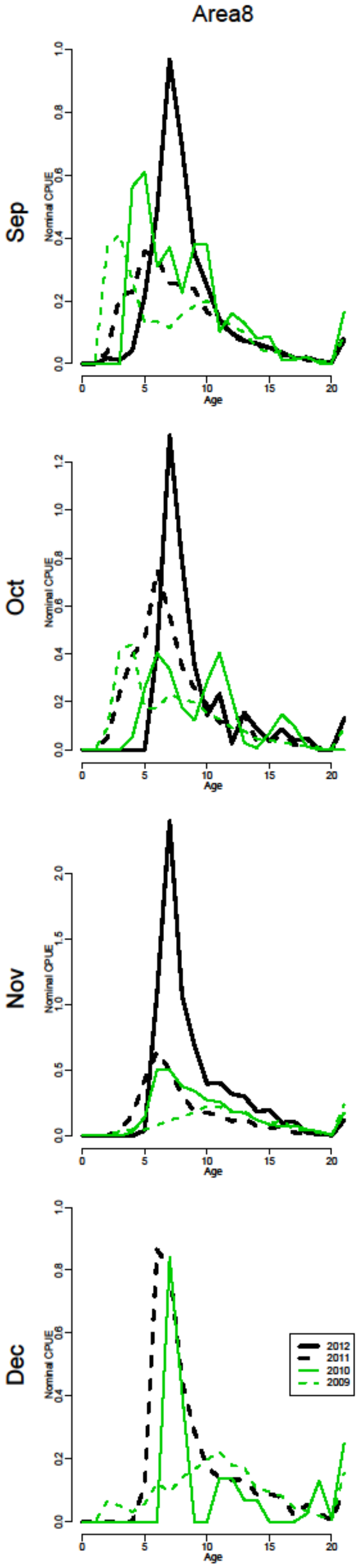
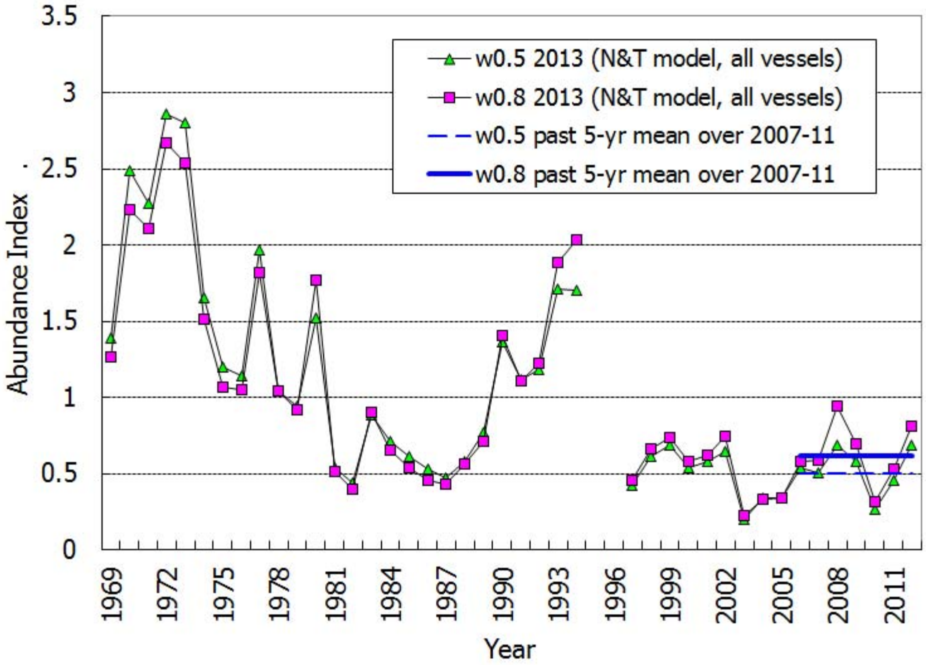


Fig. 1-4 (cont'd). Age composition of nominal CPUE of RTMP data for recent four years by month and areas.

(a) Age 3



(b) Age 4

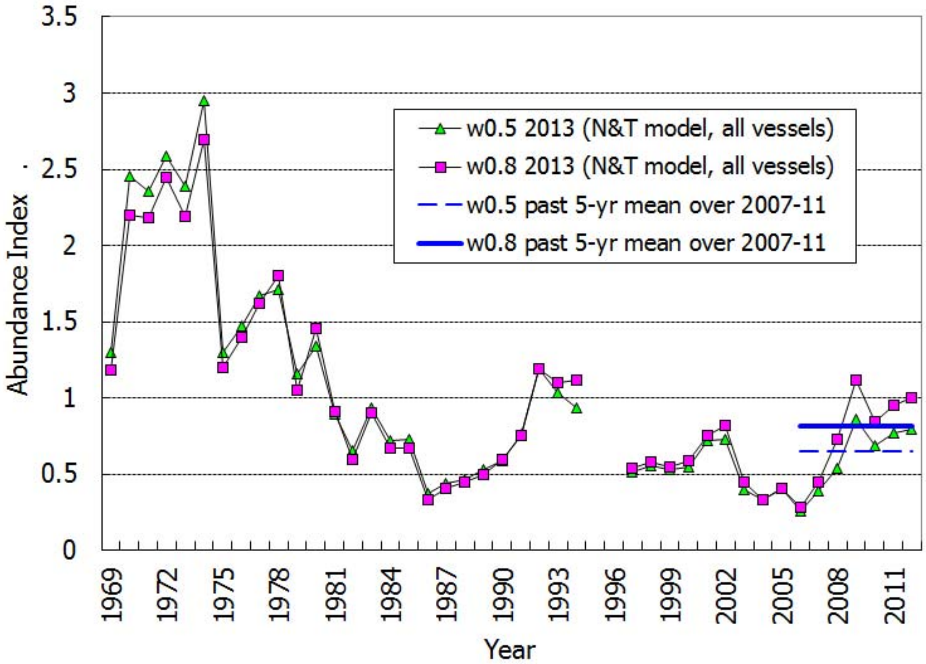
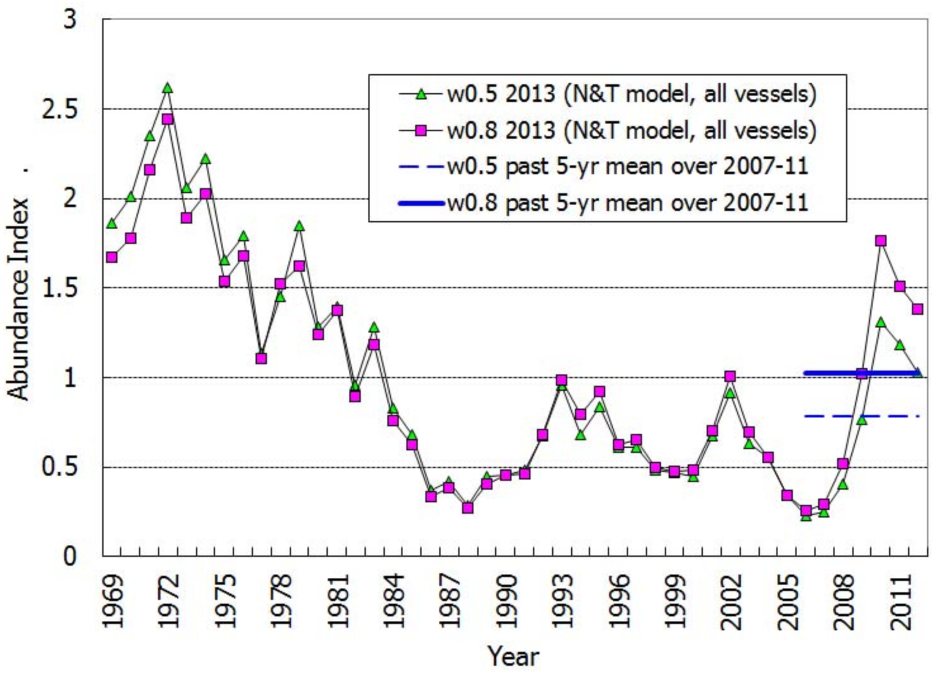


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998).

(c) Age 5



(d) Age 6&7

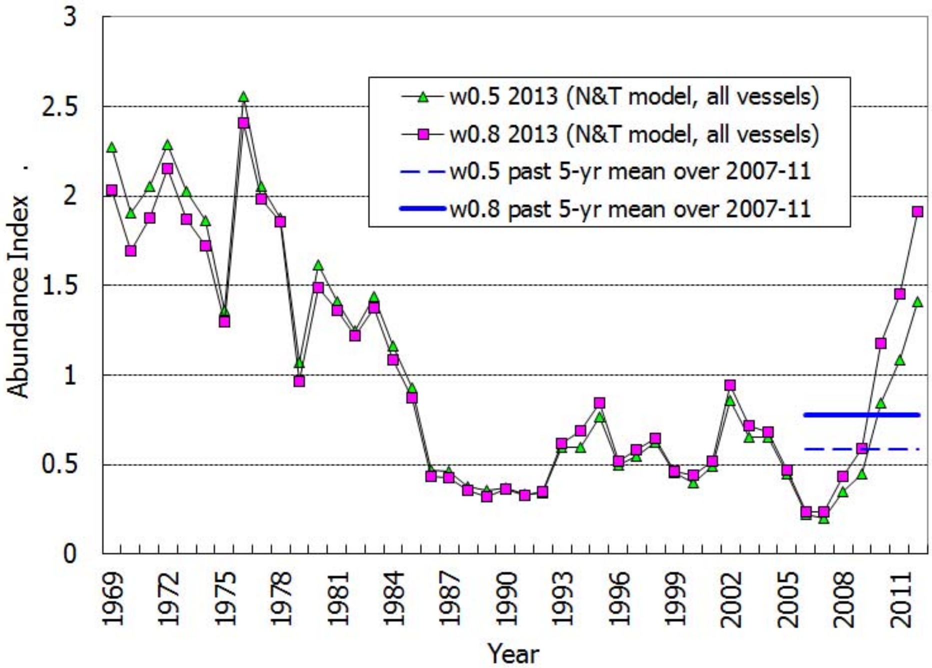
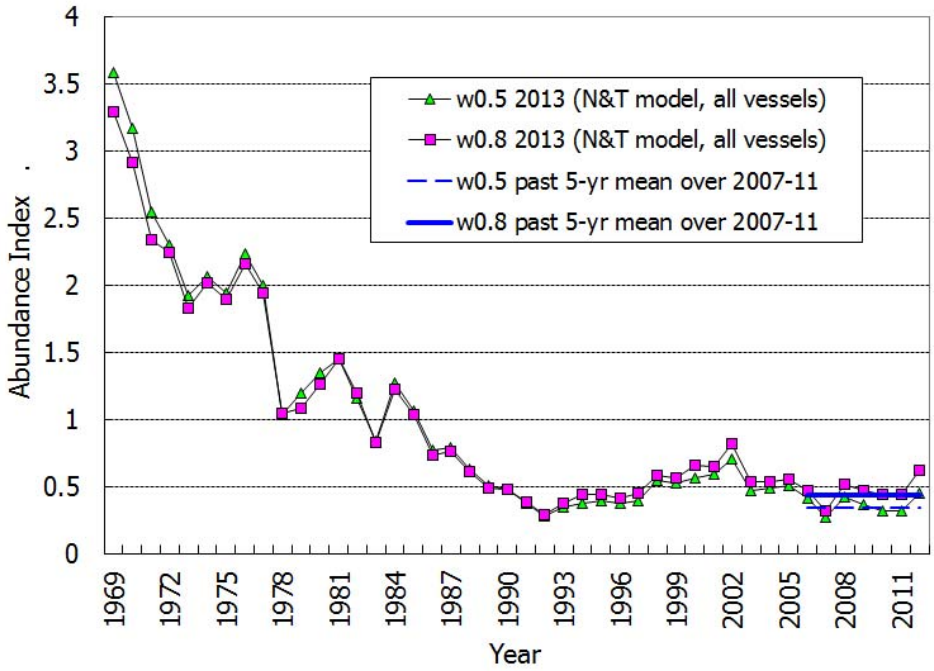


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998). (cont'd)

(e) Age 8-11



(f) Age 12+

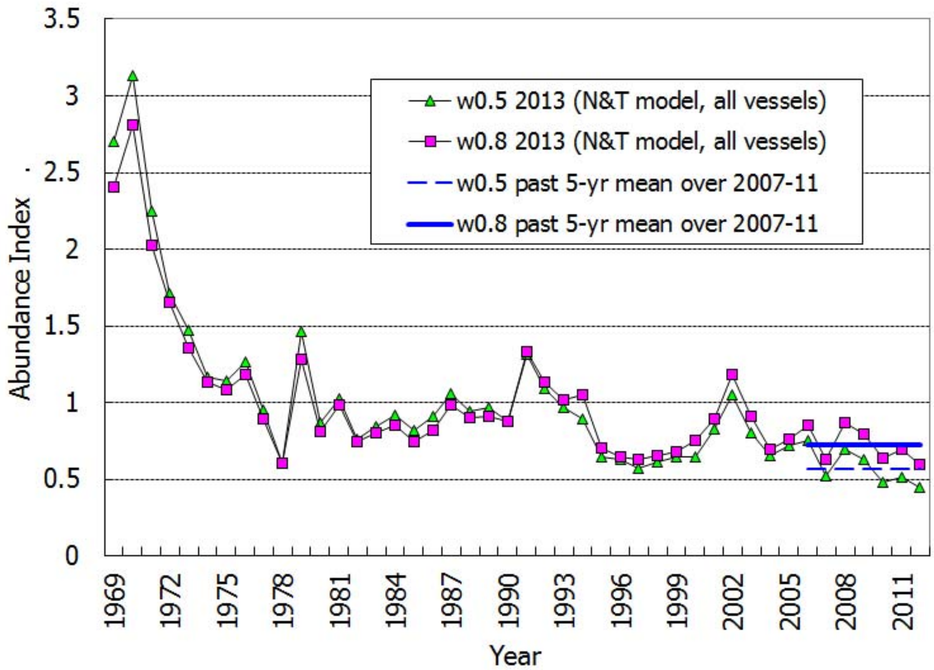


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998). (cont'd)

(g) Age 4+

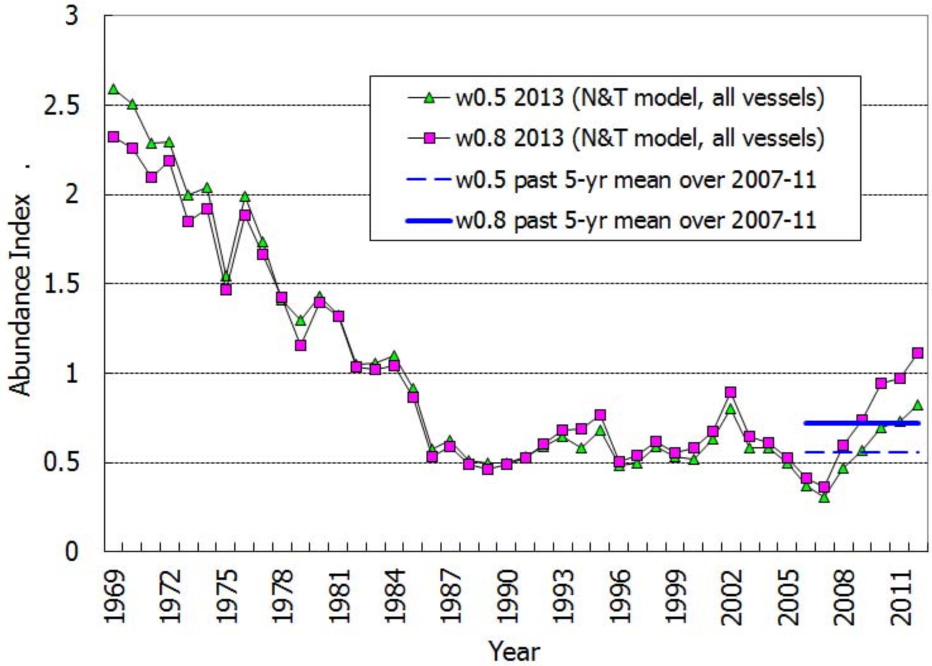
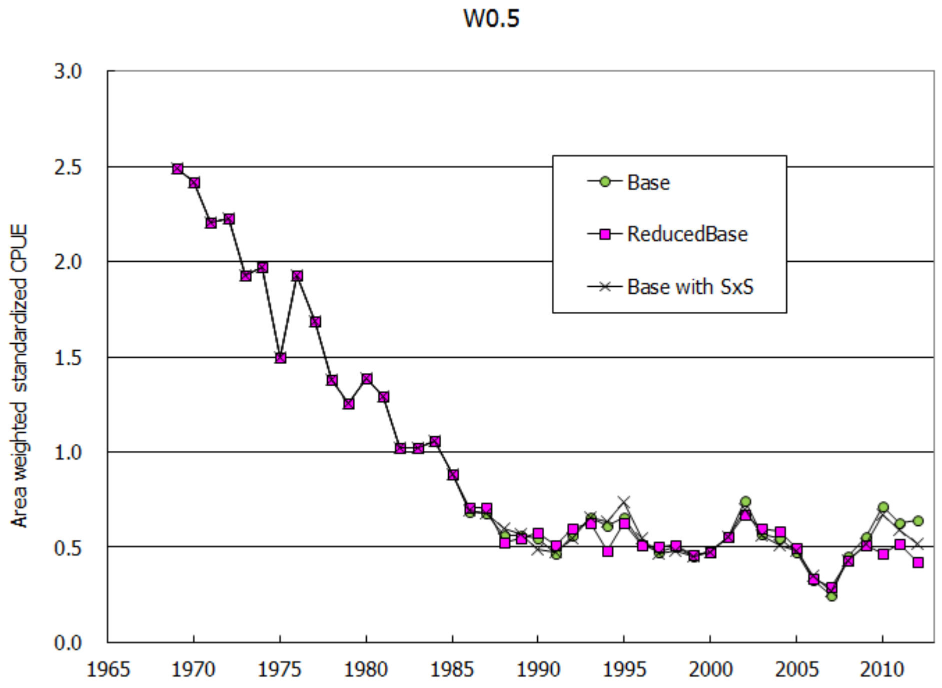


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998). (cont'd)



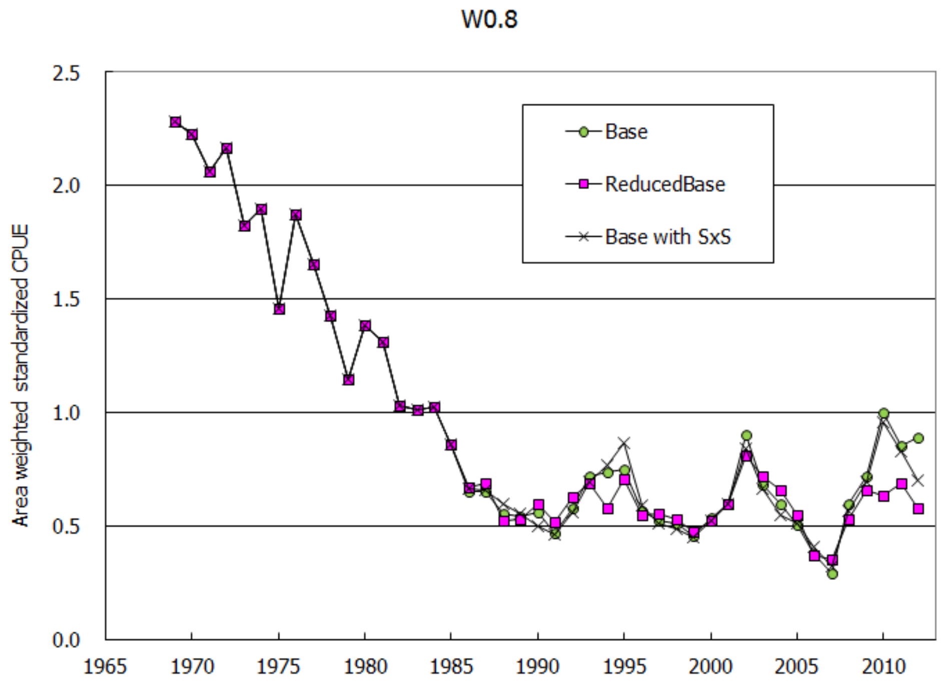


Fig. 1-6. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices using the Core Vessel data (from Itoh et al. 2013). The standardization models used were the ones agreed in the CPUE Modeling Group (CCSBT 2010).

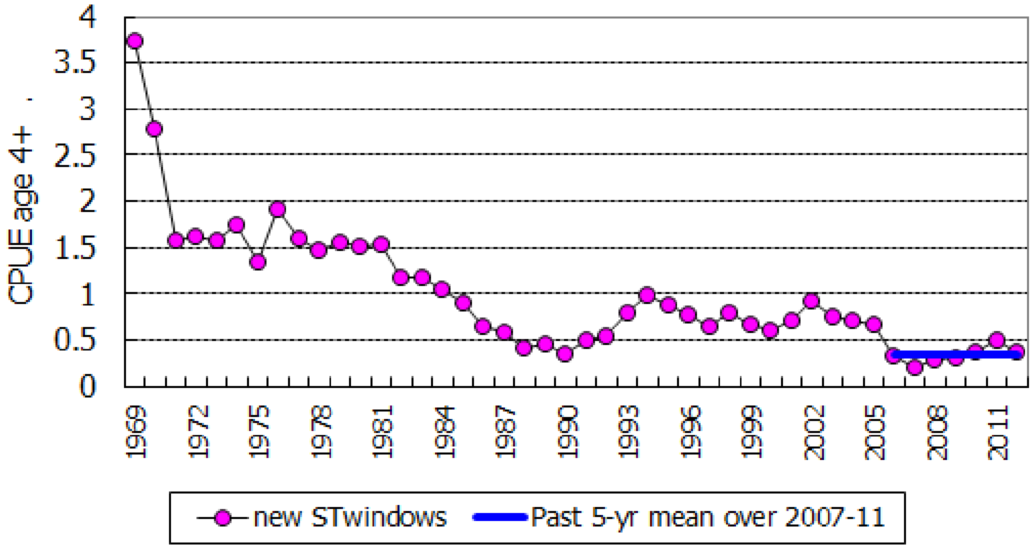


Fig. 1-7. Trend of normalized "ST Windows" index for age 4+ fish by the new calculation method.

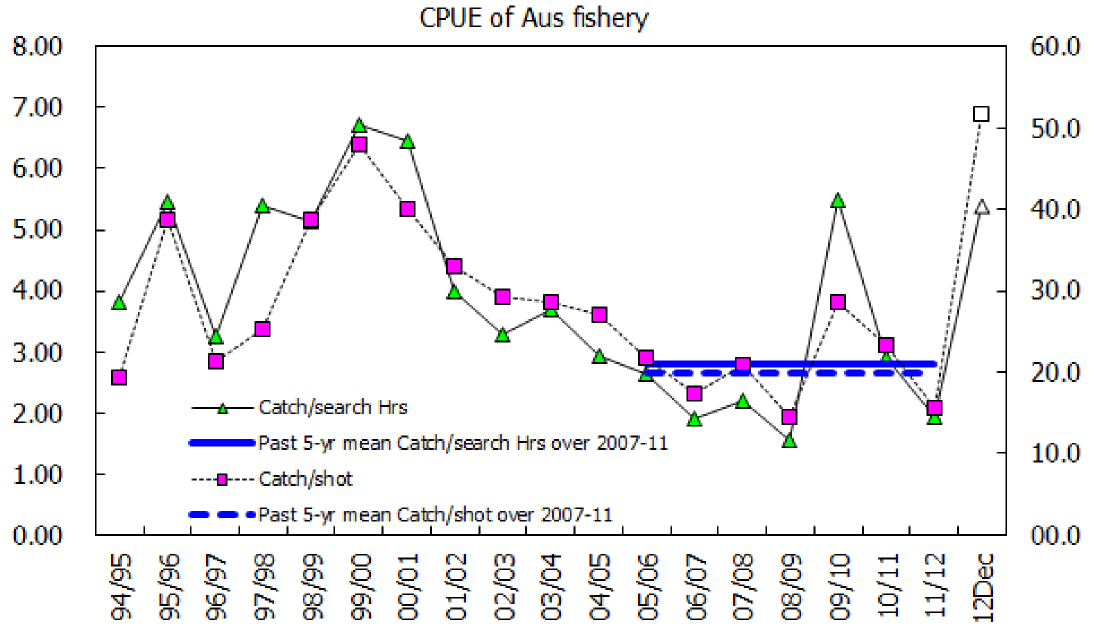


Fig. 2-1 Catch by efforts for Australia purse seine fishery.

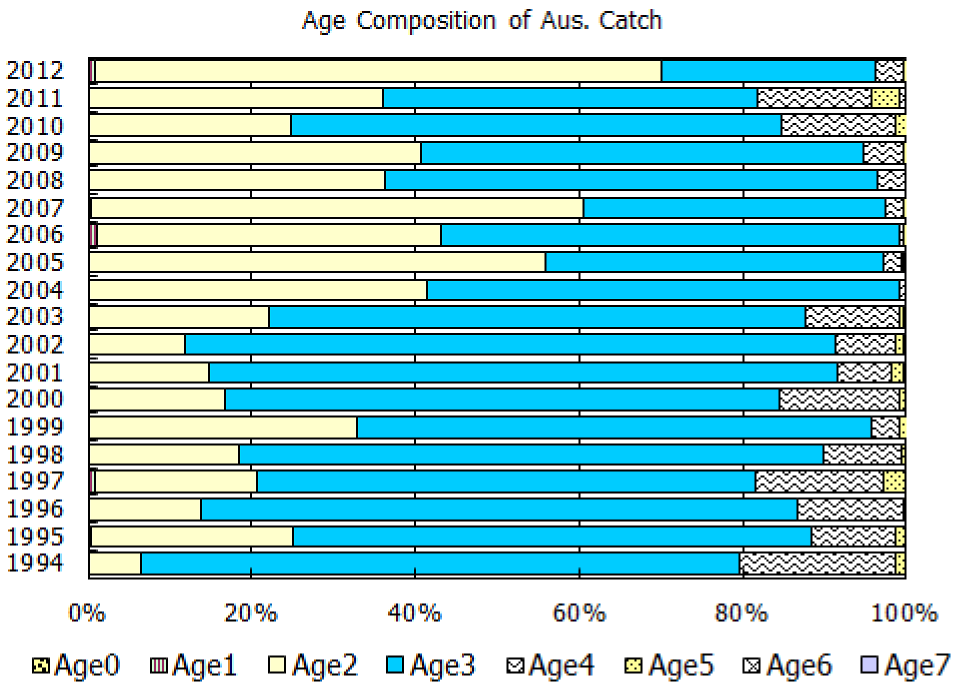


Fig. 2-2 Changes in age composition of Australia purse seine catches.

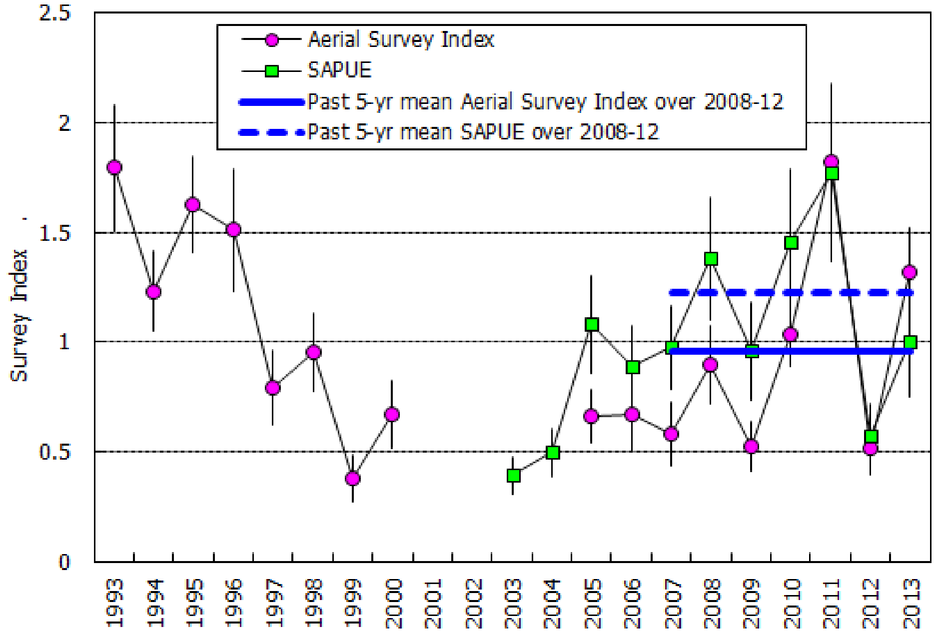


Fig. 2-3 Changes in aerial and commercial spotting (SAPUE) indices in the Great Australian Bight. Vertical bars indicate standard errors.

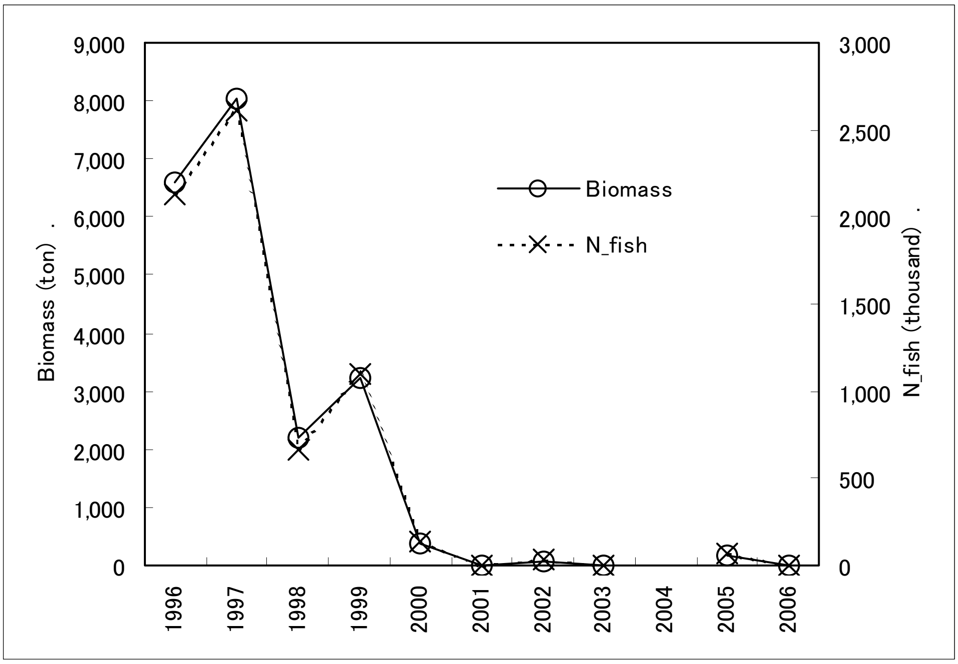


Fig. 3-1. Trends of acoustic index of age 1 SBT in the Western Australia. The acoustic survey ended in the 2005/2006 season (shown as “2006” in the figure).

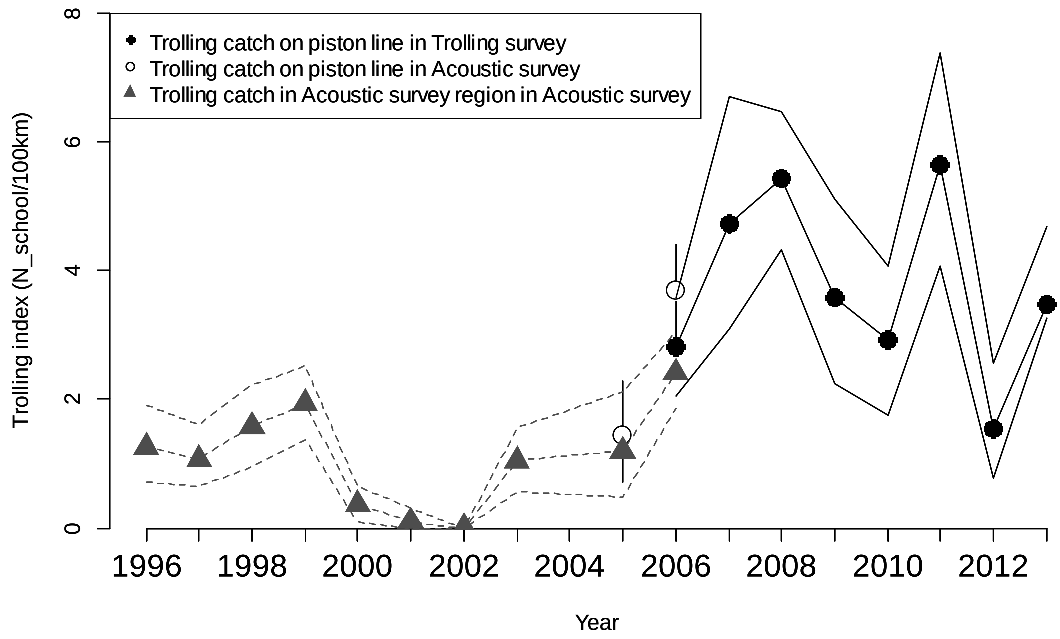


Fig. 3-2. Trends of trolling catch index of age 1 SBT in the Western Australia.

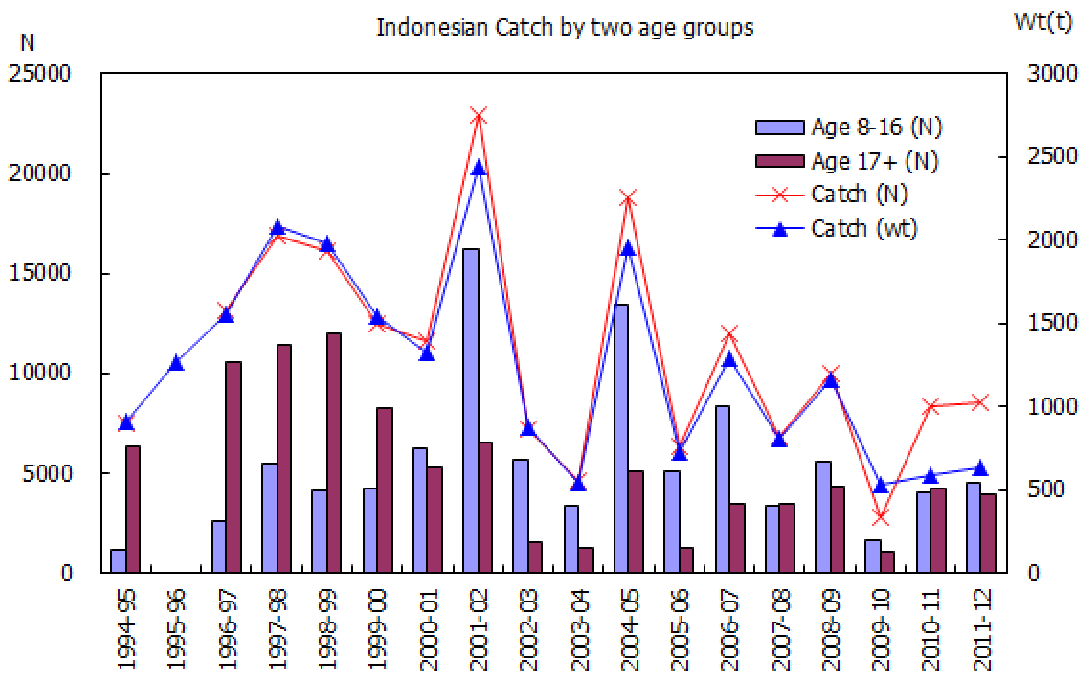


Fig. 4-1. Trends of Indonesian catches with proportion of two age groups occurrences.

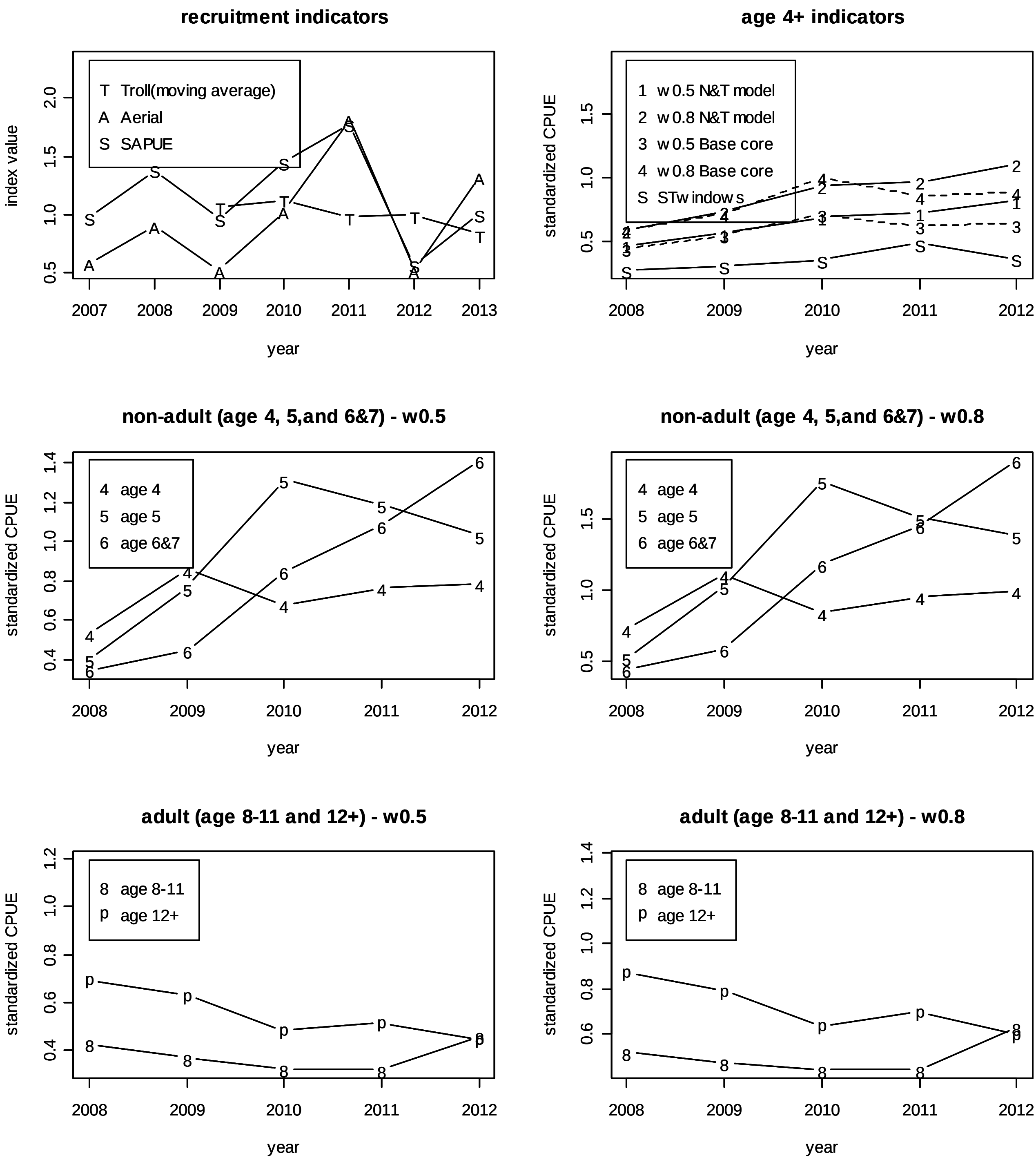


Fig. 5-1. Trends of recruitment surveys and CPUE-based indicators in recent 5 years.